

MIL-D-2759E(SH)
18 December 1987
 SUPERSEDING
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 18 October 1963
 (See 6.7)

MILITARY SPECIFICATION

DEAD RECKONING TRACER (DRT) (NAVAL SHIPBOARD)

This specification is approved for use within the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the design of Dead Reckoning Tracer (DRT) for use in Naval ships.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation.

SPECIFICATIONS

MILITARY

- MIL-E-17555 - Electronic and Electrical Equipment, Accessories, and Provisional Items(Repair Parts): Packaging of.
- MIL-E-16400 - Electronic, Interior Communications, and Navigation Equipment Naval Ship and Shore, General Specification For.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 5523, Department of the Navy, Washington, DC 20362-5101 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A

FSC 6605

DISTRIBUTION STATEMENT A Approved for public release; distribution unlimited

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2.1.2 Other Government drawing and publication. The following other Government drawing and publication form a part of this specification to the extent specified herein. Unless otherwise specified, the issues shall be those in effect on the date of the solicitation.

DRAWING

NAVAL SEA SYSTEMS COMMAND (NAVSEA)
S2487-533730 - Drafting Machine, MK 3 Mod 3, Details.

PUBLICATION

NAVY HYDROGRAPHIC OFFICE (NHO)
Publication No. 9 - American Practical Navigator.

(Application for copies should be addressed to the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20401.)

(Copies of specifications, drawings and publications required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting activity.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted shall be those listed in the issue of the DoDISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS shall be the issue of the non-government documents which is current on the date of the solicitation.

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)
236 - Inspection of Fine-Pitch Gears.

(Application for copies should be addressed to the American Gear Manufacturers Association, 1500 King Street, Suite 201, Alexandria, VA 22314.)

UNIFORM CLASSIFICATION COMMITTEE AGENT
Uniform Freight Classification Ratings, Rules and Regulations.

(Application for copies should be addressed to the Uniform Classification Committee Agent, Tariff Publication Officer, Room 1106, 222 South Riverside Plaza, Chicago, IL 60606.)

(Nongovernment standards and other publications are normally available from the organizations which prepare or which distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein (except for associated detail specifications, specification sheets or MS standards), the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

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3. REQUIREMENTS

3.1 First article. When specified in the contract or purchase order, a sample shall be subjected to first article inspection (see 4.4 and 6.4).

3.2 Operation. The DRT shall operate as follows: North and east components of own ship's distance traveled in the form of step by step signals of 115 volts direct current (Vdc) at 750 revolutions per nautical mile from dead reckoning analyzer-indicators are supplied to the DRT. These signals position the DRT plotting head so that own ship's geographic position is continuously indicated on an overlaid chart of any scale specified in 3.5.4 as the center of polar diagram and recorded as a pencil mark on plotting paper. Own ship's current position in latitude and longitude are also continuously displayed on dials.

3.3 General features. The DRT shall be in accordance with the following requirements of MIL-E-16400, in addition to the requirements specified herein:

- General requirements
- Definitions
- Materials, general
- Substitution of (equal or superior) materials or parts
- Fungus-inert materials
- Unacceptable materials
- Acceptable materials
- Flammable materials
- Arc-resistant materials
- Toxic materials
- Wood
- Metals
- Plastics
- Ceramics
- Impregnating, embedding and encapsulating compounds
- Glass
- Lubricants and lubrication
- Painting
- Protection against corrosion
- Bolts, machine screws, studs and nuts
- Gaskets
- Dials and pointers
- Dial sizes
- Locking devices
- Washers
- Ball bearings (precision grade required)
- Parts - electrical - general
- Requirements for semiconductor devices
- Electron tube or capacitor sockets
- Capacitors
- Variable resistors
- Transformers
- Relays
- Synchros
- Electrical tapes
- Batteries

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Dial illumination lamps
Switches
Indicator lights and lampholders
Fuses
Fuseholders and fuse clips
Metallic rectifiers
Printed wiring and circuits
Enclosures - general
Enclosure - accessibility
Enclosure - degree of (dripproof) (see 3.5.1)
Enclosure - mounting (see 3.5.1)
Stiffening grooves
Minimum sheet metal thickness (watertight enclosures)
Through bolting
Cable entrance
Ventilation
Size (for submarines)
Threaded devices
Rounded corners and edges
Internal subassembly protection (see 3.5.2)
Drilled tapped holes
Welding
Temperature and humidity (see 3.5.1)
Accelerated life
Shock, vibration, and inclination (vital vibration test required)(see 3.4)
Primary power supply circuits
Power supply tolerances
Personnel protection
Shielding and radio frequency noise reduction
Ground potential and grounding
Soldering
Electrical parts mounting
Internal subassembly connection
Terminal boards, connectors and terminals
Wiring
Dial illumination
Electrical insulation
Dielectric strength and insulation resistance clearances
Airborne noise
Structureborne noise
Drawings - general
Drawings - preliminary
Drawings - working
Schematic diagrams - Wiring diagram - Assembly drawings
Drawings - manufacturing
Bill of materials
Interchangeability and standardization
Manuals

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Repair parts
Repair parts (electronic)
Designation and marking
Reports
Nomenclature
Workmanship and general examination

3.4 Construction. The DRT shall be so constructed that vibration, shock, or acceleration, which may be encountered in service on board any of the types of ships for which the equipment is intended, will not adversely affect the accuracy of the equipment under normal conditions, nor, under extreme conditions, derange any part of the equipment beyond normal adjustment at sea. The equipment shall be so constructed that the operator will not receive an electric shock when making any ordinary adjustment while the equipment is in operation.

3.4.1. Excessive play between moving parts, resulting in noise when the equipment is subjected to vibration, shall be eliminated insofar as practicable.

3.4.2 The equipment and its operation shall not be adversely affected by magnetic fields up to 5 gauss.

3.4.3 Adjusting devices shall be free from excessive friction. Each adjusting device requiring a setting shall be provided with a suitable graduated dial, scale, or indicator, which shall be so constructed that it may be read without difficulty. Handles of adjusting devices shall be so constructed or protected that accidental contacts will not disturb them or change their setting or shall be provided with protective covers attached to the unit in such a manner as not to cause interference or affect ease of handling.

3.4.4 Resolvers, friction disks, rollers, and other mechanical components shall be of a suitable material, properly and evenly hardened or treated to prevent wear. They shall, wherever practicable, be provided with oil-saturated felt wipers for lubrication.

3.4.5 Bearings shall be double-shielded, shall be at least class ABEC3, and shall be the prelubricated sealed-for-life type.

3.4.6 Viewing windows, where required, shall be so mounted as to minimize danger of breakage or cracking due to stress at the edges.

3.4.7 Electrical connections from each unit to external circuits shall be brought out to common termination connectors.

3.4.8 Parts of the equipment requiring accurate placing shall be marked or doweled, so that when disassembled for repairs or adjustments, the parts may be replaced in their proper position. Parts requiring occasional renewal due to unavoidable service wear shall be constructed for maximum practicable ease of replacement.

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3.4.9 Interchangeability. In no case shall parts be physically interchangeable or reversible unless such parts are also interchangeable or reversible with regard to function, performance and strength.

3.4.10 Proposed changes in design affecting interchangeability of parts of assemblies, including repair parts, shall be satisfactory to the Command or agency concerned before being made effective.

3.4.11 Terminal boards shall be provided with protective covers to prevent accidental short circuits while working on the tracer.

3.4.12 The effect of roll and pitch shall not adversely affect the operation of any unit of equipment (see 4.6.2)

3.4.13 Provision shall be made to protect the DRT against possible damage in case the equipment is allowed to run to or beyond its operating limits.

3.4.14 Mercury and radium, in any form, shall not be used in this equipment nor in the manufacture or test of this equipment.

3.4.15 All cable shields shall be tied to a common point and grounded at that point within the equipment.

3.4.16 Gears. Gears used in critical backlash applications shall be at least sixty-four pitch and precision 1C as defined by AGMA 236 and of a material satisfactory to the Command or agency concerned. Corrosion resisting steel gears may be used where this material will provide superior performance. Low torque, high precision gears shall not be lubricated unless they are fully sealed in an enclosure.

3.5 Mechanical features.

3.5.1 Enclosure. All parts required for the proper operation of the DRT shall be mounted in an enclosing case (degree of enclosure dripproof or better) constructed for horizontal mounting. Provision shall be made for the protection of gears from dust. Mounting and external wiring of the equipment shall be accomplished without removal of components from the enclosure and without exposing the gears to dust. Internal subassemblies shall not be supported by the enclosure. Adequate natural ventilation shall be provided to permit proper operation at any ambient temperature within the limits specified in MIL-E-16400.

3.5.2 Accessibility. All units and subassemblies of the equipment shall be easily accessible for replacing plotting paper, adjustment plotting section and the control section access doors shall be equipped with hinges and brackets so that they lock in the open position. Protection of the internal subassemblies shall be provided in accordance with MIL-E-16400.

3.5.3 Weight and size. The effective plotting area shall be not less than 30 by 30 inches. The vertical thickness of the DRT shall not exceed 6 inches. The overall weight and size of the DRT shall be kept to a minimum.

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3.5.4 The scale of the track shall be adjustable and through a gear shift arrangement shall provide for the following ranges: 200 yards per inch; 1/4 to 1 nautical mile per inch; 1 to 4 nautical miles per inch; 4 to 16 nautical miles per inch. The adjustment shall be indicated on a scale reading to hundredths of a nautical mile per inch over the lower variable range.

3.5.5 The track shall indicate intervals of time by interruption of the track for approximately 15 seconds each minute and additional interruption for 1 minute every 10 minutes. The timing shall be controlled by an 8-day clock which shall be accurate within 3 minutes at all times during a period of 96 hours when wound every 24 hours, irrespective of whether the track timing contacts are in operation. The contacts shall have ample clearance in the open position, and shall not impose an unduly heavy or variable load on the clock mechanism.

3.5.6 The track shall be clearly defined and shall be uniform irrespective of the position in which the tracer is operated.

3.5.7 Provision shall be made for conveniently starting the track at any point in the tracking area, correcting the position of the tracking mechanism, changing the scale of the track, and making all other normal operating adjustments and observations without moving the auxiliary plotting board.

3.5.8 The tracking device shall not cut, tear, or unduly abrade the chart paper when run back and forth repeatedly over the same course. The tracking device shall be satisfactorily protected against breakage of pencil lead when the tracer is subjected to shock in any position.

3.5.9 Provision shall be made for starting and stopping the mechanism of the tracer.

3.5.10 Provision shall be made for electrically interchanging the course components to permit shifting the reference axes of the tracking mechanism at right angles. Label plates shall be provided, suitably marked, to indicate the directions of north, south, east, and west.

3.5.11 The tracking board shall be smooth and free from surface irregularities and shall be flat within 1/16 inch from highest to lowest point.

3.5.12 The upper frame of the plotting section shall allow installation of the mounting plate of the drafting machine MK3 Mod 3 (see Drawing S2487-533730).

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3.5.13 The tracer shall be equipped with an auxiliary plotting board in accordance with the design that is satisfactory to the Command or agency concerned. The plotting surface shall be a tempered glass plate sufficiently strong to serve the purpose, spaced above the tracking area for use in connection with a screen dial assembly. The screen dial assembly shall be constructed for attachment to the pencil carrier, and shall include a light source, a screen dial, and a suitable light shield, so arranged as to project a shadow image of the screen dial to a chart placed on the plotting surface. The screen dial and the size of the projected image shall be in accordance with designs satisfactory to the Command or agency concerned. Means shall be provided for optional use of this method of tracking, or pencil tracking, or both methods together. When both methods are used simultaneously, the time element in the pencil track (see 3.5.5) will not be required.

3.5.14 The tracer MK6 shall contain a latitude and longitude computer element which will compute and indicate latitudes up to 85 degrees north or south and compute and indicate longitude from 0 up to 180 degrees east and west. Provisions shall be made for manual resetting of the dials. Dials shall read to an accuracy of 1 minute of arc.

3.6 Power supply. The equipment shall operate on ship's supply, 115-volt, 60-hertz (Hz), single phase, alternating current and 115 Vdc.

3.7 Accuracies. The error of the plotting system shall not exceed the values shown below under all conditions specified in 4.6.1

- (a) Resultant error - 0.5 percent.
- (b) Position error - 2.0 percent.

3.8 Error calculations. The distance input to the equipment is defined as the theoretical length of run in nautical miles, and is represented by D. The distance input to a tracer is determined by the output of the distance transmitter. The distance output is determined by actual measurement on the plotting surface.

3.8.1 Resultant error. The resultant error is the error in the resultant north-south, east-west component miles of the DRT output, and is expressed by the following formula:

$$E_r = \frac{100 \times E^2 + N^2}{D}$$

Where:

- E_r = Resultant error, in percent.
- D = Length of run in nautical miles, determined from the distance input to the unit.
- E = The difference in the measurement of the east component of plotting head position and the E-W component of the distance input.
- N = The difference in the measurement of the north component of plotting head position and the N-S component of the distance input.

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3.8.2 Position error. The position error is the error in final position indicated by the latitude and longitude dials, measured from the calculated final position as computed by the Mercator sailing method (NHO Publication No. 9) and expressed in percent of the total theoretical distance input to the unit. (The method of computing the position error is shown in the appendix to this specification.)

3.9 The contractor shall furnish accurate information on weight and vertical center-of-gravity (v.c.g.) of each unit of equipment, weighing 100 pounds or more, as well as items known to be stowed or group-located in quantity so as to constitute an aggregate weight of 100 pounds or more. This information shall be required as follows (see 6.3):

- (a) By notation of calculated weight and location of v.c.g. on the outline drawing initially submitted for approval.
- (b) On all revisions of drawings which result from changed in calculations, under (a) above.
- (c) By notation of the actually measured weight and corrected location of v.c.g., made prior to shipment, on the final revision of the drawings sent to the Government.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items must meet all requirements of sections 3 and 5. The inspections set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

4.2 Classification of inspections. The inspection requirements specified herein are classified as follows:

- (a) First article inspection (see 4.4).
- (b) Quality conformance inspection (see 4.5).

4.3 First article inspection. One sample of the DRT equipment shall be subjected to the examination and tests shown in table I. Tests shall be performed in general in the order listed.

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TABLE I. First article inspection.

Examination and tests	Requirement	Test
General examination	3.3	4.5
Shielding and radio frequency noise reduction	3.3	MIL-E-16400
Airborne noise	3.3	MIL-E-16400
Structureborne noise	3.3	MIL-E-16400
Effect of pitch and roll	3.4.12	4.2
Enclosure	3.3 and 3.5.1	MIL-E-16400
Effect of magnetic fields	3.4	4.6.3
Accuracy	3.7	4.6.1
Accelerated life (includes tests for supply line voltage, accuracy temperature and humidity, dielectric strength, insulation resistance, shock, vibration and inclination)	3.3	4.6.4 and MIL-E-16400

4.4 Quality conformance inspection.

4.4.1 Group A. All equipment offered for delivery on the contract or order shall be subjected to the group A examination and tests specified in table II. Any equipment failing to meet requirements of this specification shall not be offered for delivery.

TABLE II. Group A examination and tests.

	Requirement	Test
General examination	3.3	4.5
Dielectric strength ^{1/}	3.3	MIL-E-16400
Insulation resistance ^{1/}	3.3	MIL-E-16400
Accuracy ^{2/}	3.7	4.6.1
Supply line voltage	3.3	MIL-E-16400

^{1/} For all but rotating components of equipment.

^{2/} See 4.6.1.3.

4.4.2 Group C. Group C tests, specified in table III, shall be conducted on one complete equipment when the basic design of the equipment or the material of a vital part has been changed.

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TABLE III. Group C tests.

	Requirement	Test reference
Accelerated life	3.3	4.6.4
Enclosure	3.3 and 3.5.1	MIL-E-16400
Vibration	3.3	MIL-E-16400
Shock	3.3	MIL-E-16400
Airborne noise	3.3	MIL-E-16400
Effect of magnetic fields	3.4.2	4.6.3
Effect of pitch and roll	3.4.12	4.6.2

4.5 General examination. The general examination shall be conducted in accordance with MIL-E-16400.

4.6 Test procedures.4.6.1 Accuracy.

4.6.1.1 Resultant error. The resultant error test shall be conducted currently with the test for accuracy position. Both tests shall be conducted using the runs described in table IV. Resultant errors shall be determined as specified in 3.8.1 for each run.

TABLE IV. Accuracy test runs.

Run	D	L ₁	Course	Resultant error test			Accuracy of position test				K
				D _N	D _E	R	DL		DL ₀		
		De-grees	True azimuth	Miles	Miles	Miles	De-grees	Minutes	De-grees	Minutes	
a	100	0	030	86.603	50.000	100	1	27.04	0	49.88	1.001
b	100	15S	150	86.603	50.000	100	1	26.97	0	51.90	0.961
c	100	25N	240	50.000	86.603	100	0	50.16	1	34.09	.915
d	100	40S	300	50.000	86.603	100	0	50.04	1	52.06	.778
e	100	55N	045	70.711	70.711	100	1	10.57 ^{2/}	2	04.6 ^{2/}	.539
f	100	65S	270	0.0	100.000	100	0	0.0	3	55.53	.425
g	100	85N	090	0.0	100.000	100	0	0.0	19	01.34	.088
h ^{1/}	500	40N	045	353.56	353.56	500	5	53.65	8	02.0	.700
j	1000	40N	045	707.11	707.11	1000	11	46.92	16	58.0	.621

^{1/} Data for run "h" shall be obtained when practicable by making a stop for readings at 500 nautical miles during run "j".

^{2/} Values of DL and DL₀ for accuracy check runs on alternate courses 135 and 225 degrees are: DL 1 degree, 10.59 minutes, DL₀ 2 degrees, 01.0 minutes (see 4.6.1.2)

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4.6.1.2 Position error. The test for accuracy of position shall include the seven runs of 100 nautical miles each and one run of 1000 nautical miles shown in table IV (see appendix for definition of abbreviations and method of computation). Accuracy checktests required by MIL-E-16400 shall consist of run "e" only of table IV. This accuracy check test shall be conducted four times on courses 045, 135, 225, and 315 to determine equal accuracy in all quadrants of ships' motion.

4.6.1.3 Accuracy (group A inspection). When conducting quality conformance inspection, group A (see table II), the accuracy tests required may be reduced to runs "a", "b", and "g" only, if the results of the reduced tests meet the requirements of 3.7.

4.6.2 Effect of roll and pitch. The purpose of this test shall be to determine whether the DRT will operate satisfactorily under condition of roll and pitch.

4.6.2.1 Unit Test. The unit under test shall be mounted on a Scorsby test stand which shall be operated during the runs with amplitude of roll of 40 degrees on each side of the vertical with a period of between 8 and 10 seconds, and an amplitude of pitch of 10 degrees on each side of the vertical with a period of between 6 and 8 seconds. The unit may be mounted in any one or more positions in which it may be required to operate abroad and the roll and pitch axes of the Scorsby test stand may be interchanged, if necessary, to provide clearance for the motion of the unit.

4.6.3 Effect of magnetic fields. Tests shall be made to ensure that a magnetic field will not affect the accuracy of the DRT as specified in 3.4.2.

4.6.4 Accelerated life. The accelerated life test shall be conducted as specified in MIL-E-16400 with a constantly varying course input synchro signal of 360 degrees per minute in each direction, and a constantly varying speed input synchro speed of single harmonic motion of from 5 to 35 knots with a 60 second period for 250 hours. The heat dissipated from the sides and back of the equipment shall be restricted by means of low heat conducting bulkheads placed adjacent to the sides and back of the equipment.

4.7 Inspection of packaging. Sample packages and packs, and the inspection of the presevation-packaging, packing and marking for shipment and storage shall be in accordance with the requirements of section 5 and the documents specified therein.

5. PACKAGING

(The packaging requirements specified herein apply only for direct Government acquisition. For the extent of applicability of the packaging requirements of referenced documents listed in section 2, see 6.5.)

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5.1 Domestic shipment and early equipment installation and for storage of of on board repair parts.

5.1.1 Dead reckoning tracer.

5.1.1.1 Preservation and packaging. Packing shall be accomplished in a manner which will insure acceptance by common carrier and will afford protection against physical or mechanical damage during direct shipment from the supply source to the using activity for early installation. The shipping containers or method of packing shall conform to the Uniform Freight Classification Rules and Regulations or other carrier regulations as applicable to the mode of transportation, and may conform to the contractor's commercial practice when such meets these requirements.

5.1.2 On board repair parts. On board repair parts shall be preserved and packaged by level A; packed by level C, and marked by levels A and C respectively in accordance with MIL-E-17555.

5.2 Domestic shipment and storage or overseas shipment. The requirements and levels of preservation and packaging, packing, and marking for shipment shall be as specified (see 6.2).

5.2.1 The following provides various levels of protection during domestic shipment and storage or overseas shipment, which may be required when acquisition is made.

5.2.1.1 Preservation and packaging, packing and marking. The equipment and accessories, repair parts and technical publications shall be preserved and packaged by levels A or C; packed by levels A or B as specified, and marked in accordance with MIL-E-17555.

6. NOTES

6.1 Intended use. The equipment covered by this specification is intended for Naval service where it is expected to withstand continuous use for long periods, under Military service conditions without benefit of overhaul. The equipment is in each case a vital instrument intended for important use by the forces concerned. Failure at a critical moment invariably results in serious reduction in the battle efficiency of the ship. The DRT is intended to indicate and record own ship's dead reckoning position graphically and to indicate latitude and longitude on dials or counters.

6.2 Ordering data. Acquisition documents should specify the following:

- (a) Title, number, and date of this specification.
- (b) Inventory control point for repair parts (see 3.4).
- (c) Whether unit National Stock Number is to be entered on the identification plate (see 3.4).
- (d) Quantity of manuals required (see 3.4).
- (e) Preservation, packaging, packing, and marking required if other than as specified in 5.1 (see 5.2).

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6.3 Bid data. Bidders shall be required to furnish the following (see 3.9):

- (a) Information on weight and v.c.g. of each unit of equipment weighing 100 pounds or more.
- (b) Items known to be stowed or group located in quantity so as to constitute an aggregate weight of 100 pounds or more.

6.4 First article. When a first article inspection is required, the item should be a first article sample. The first article should consist of one unit. The contracting officer should include specific instructions in acquisition documents regarding arrangements for examinations, approval of first article test results and disposition of first articles. Invitations for bids should provide that the Government reserves the right to waive the requirement for samples for first article inspection to the bidders offering a product which has been previously acquired or tested by the Government, and that bidders offering such products, who wish to rely on such production or test, must furnish evidence with the bid that prior Government approval is presently appropriate for the pending contract.

6.5 Sub-contracted material and parts. The packaging requirements of referenced documents listed in section 2 do not apply when material and parts are acquired by the contractor for incorporation into the equipment and lose their separate identity when the equipment is shipped.

6.6 Subject term (key word) listing.

Distance
Latitude
Longitude
Position
Resolver

6.7 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Preparing activity:
Navy - SH
(Project 6605-N373)

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APPENDIX

COMPUTATIONS

10. Definition of abbreviations. The abbreviations used in describing the methods of computing positions are as follows:

- D - Distance of run in nautical miles.
 L_1 - Initial latitude setting.
 L_2 - Calculated final latitude.
 L_M - Estimated middle latitude.
 Course angle - Direction of movement measured in degrees in direction from true north and south.
 C - Course setting- Direction of movement measured in degrees clockwise from true north.
 DL - Difference in latitude between initial setting and final counter reading.
 DL_0 - Difference in longitude between initial setting and final counter reading.
 K - The value of nautical miles per minute of longitude at the final latitude.

20. Method of computing.

20.1 The Mercator method of computing the calculated final position for all runs except when the course is 90 degrees or 270 degrees is shown in the following example (calculations for run "d"):

- (a) Given initial latitude = $40^{\circ}00.0'S = L_1$
 initial longitude = $0^{\circ}00.0'E$
 course = $300^{\circ} = C$
 distance = 100 miles = D
- (b) $D_E = 100 \sin 60^{\circ} = 86.603$ miles
 $D_N = 100 \cos 60^{\circ} = 50.000$ miles
 $L_M = L_1 + 1/2 D_N$ (1 mile = 1 minute of latitude)
 $= 40^{\circ}00.0'S + 25.0' = 40^{\circ}25.0'S$

- (c) The difference in latitude is:

$$DL = 100 \cos 60^{\circ} \times \frac{60.000}{59.949} = 50.043$$

in which 59.949 is the value of miles per degree of latitude at the estimated middle latitude (L_M), from table 6 in Bowditch NHO Publication No. 9.

- (d) The final latitude is:

$$L_2 = L_1 + DL = 40^{\circ} 00.0' - 50.043' = 39^{\circ} 09.557'S$$

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APPENDIX

- (e) From explanation of table 5 in Bowditch, the meridional parts for the initial latitude is:

$$m_1 - 2607.7$$

- (f) Similarly the meridional parts for the final latitude is:

$$m_2 - 2542.5$$

- (g) The difference in longitude is:

$$\begin{aligned} DL_o &= (m_2 - m_1) \tan C \\ &= 65.2 \tan 60^\circ \\ &= 112.92' = 1^\circ 52.92' \end{aligned}$$

20.2 When the course is 90 or 270 degrees, the final position is computed by the Middle Latitude sailing method, as shown in the following example:

- (a) Given $L_1 = 65^\circ 00.0'S$
 $C = 270^\circ$
 $D = 100$ miles

- (b) The difference in latitude is zero.

- (c) The difference in longitude is:

$$DL_o = 100 \sin 270^\circ \times \frac{60.000}{25.474} = 3^\circ 55.53'$$

in which 25.474 is the value of miles per degree of longitude corresponding to 60° latitude (the mean latitude during the run) (from table 6 in Bowditch).

20.3 The position error is computed as shown in the following example (calculated for run "d"):

- (a) Given: Observed values:

$$\begin{aligned} DL & 0^\circ 50.7' \\ DL_o & 1^\circ 50.5' \end{aligned}$$

From table IV

$$\begin{aligned} DL & 0^\circ 50.04' \\ DLO & 1^\circ 52.06' \\ K & 0.778 \end{aligned}$$

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- (b) The latitude error is:

$$0^{\circ} 50.7' - 0^{\circ} 50.0' = 0.7'$$

Since the errors are small as compared with the total distance, 1 minute of latitude may be considered as equal to 1 nautical mile. Then

$$\text{north component error} = 0.7 \text{ mile.}$$

- (c) The longitude error is:

$$1^{\circ} 50.5' - 1^{\circ} 52.1' = 1.6$$

The value K of miles per minute of longitude may be found by dividing the value of miles per degree at the final latitude (from table 6 in Bowditch) by 60.

$$K = \frac{46.7}{60.0} = 0.778$$

The east component error is K times the longitude error in minutes, or 1.24 miles.

- (d) The position error is the vector sum of the north and east component errors, expressed in percent of the distance, or

$$\begin{aligned} E_p &= \sqrt{(1.24)^2 + (0.7)^2} \times \frac{100}{100} \\ &= \sqrt{2.03} \times \frac{100}{100} = 1.42 \text{ percent} \end{aligned}$$

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER MIL-D-2759E(SH)	2. DOCUMENT TITLE DEAD RECKONING TRACER (DRT) (NAVAL SHIPBOARD)
3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION (Mark one) <input type="checkbox"/> VENDOR <input type="checkbox"/> USER <input type="checkbox"/> MANUFACTURER <input type="checkbox"/> OTHER (Specify): _____
b. ADDRESS (Street, City, State, ZIP Code)	
5. PROBLEM AREAS	
a. Paragraph Number and Wording:	
b. Recommended Wording:	
c. Reason/Rationale for Recommendation:	
6. REMARKS	
7a. NAME OF SUBMITTER (Last, First, MI) – Optional	7b. WORK TELEPHONE NUMBER (Include Area Code) – Optional
c. MAILING ADDRESS (Street, City, State, ZIP Code) – Optional	8. DATE OF SUBMISSION (YYMMDD)